KANSAS GEOLOGICAL SURVEY
The University of Kansas

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The U.S. Geological Survey has been studying occurrences of induced seismicity, or earthquake activity related to the injection of fluids into the subsurface. This work is being coordinated with other federal agencies, including the Environmental Protection Agency and the U.S. Department of Energy.

Recently U.S.G.S. researchers published an abstract of a paper that was presented at an April 18 meeting of the Seismological Society of America. That paper documented an increase in small earthquakes in the midcontinent, particularly in Oklahoma and Arkansas, and noted an increase in small seismic events in the area west of Trinidad, Colorado, along the Colorado/New Mexico border. That is an area of coalbed methane production and associated fluid disposal. That abstract, and news reports based on it, renewed concerns about induced seismicity. In light of those reports, it's important to understand the following.

1) Induced seismicity has not been related to hydraulic fracturing. The U.S.G.S. has stated that there is "no evidence to suggest that hydraulic fracturing itself is the cause of the increased rate of earthquakes" in the midcontinent. As noted by Stanford University geophysicist Mark Zoback, "the pressurization during hydraulic fracturing affects only limited volumes of rock (typically several hundred meters in extent) and pressurization typically lasts only a few hours." Rick Miller, a geophysicist at the Kansas Geological Survey, has said that there is no evidence to support a connection between hydraulic fracturing and earthquakes. "Because stress has to accumulate along a rupture zone to produce earthquakes, the distributed nature of fracking does not lend itself to large earthquakes."

2) The U.S.G.S. study, and other research, has found that "at some locations the increase in seismicity coincides with the injection of wastewater in deep disposal wells." Significant amounts of saltwater are produced along with oil and gas in U.S., including Kansas. This saltwater is generally injected back into

the deep subsurface. Nationally, the U.S.G.S. estimates that there are 150,000 injection wells (called Class II wells by the EPA), of which 40,000 are used to dispose of the waste fluids from oil and gas operations. Again, it is important to remember that those fluids are the result of any oil and gas production, and independent of the practice of hydraulic fracturing. Like most oil and gas production-enhancement procedures, hydraulic fracturing produces non-potable water that requires disposal under State permits. There are approximately 16,000 Class II wells in Kansas. They are regulated by the Kansas Corporation Commission. There are 47 Class I disposal wells in Kansas, used to dispose of hazardous or non-hazardous industrial waste. These are regulated by the Kansas Department of Health and Environment.

3) It has long been known that earthquakes can be triggered by fluid injection. As Zoback noted, "The first well-studied cases were earthquakes triggered by waste disposal at the Rocky Mountain arsenal near Denver in the early 1960s and by water injection at the Rangely oilfield in western Colorado in the late 60s and early 70s." As the U.S.G.S. notes, "We know that the Earth's crust is pervasively fractured at depth by faults. These faults can sustain high stresses without slipping because natural "tectonic stress and the weight of the overlying rock pushes the opposing sides of the fault together, increasing the frictional resistance to fault slip. The injected wastewater in deep wells can counteract the frictional forces on faults, causing an earthquake." In other words, fluids injected near a fault can, in effect, act as a friction-reducing agent, allowing a fault to move. It is equally important to remember, however, that these fluids allow energy "already stored in brittle rock formations to be released in earthquakes. These earthquakes would someday have occurred anyway as a result of slowly accumulating forces in the earth result from natural geologic processes—injection just speeds up the process." That is also why induced seismicity is sometimes called "triggered seismicity."

4) In general, in Kansas, waste fluids from oil and gas production are injected back into deep subsurface formations that take those fluids "under gravity." That is, because of the ability of these formations to accept substantial amounts of fluid, fluids are not injected under additional pressure, but simply allowed to flow into these rock formations under the force of gravity. As the Kansas Department of Health and Environment has noted, "Gravity injection allows only the amount of fluid to be injected that the formation can naturally accept, thereby limiting pressure build-up in the disposal formation reducing the potential of rock movement at a fault. Any pressure increases that do occur from injection are limited to the vicinity of the well, which also decreases the

likelihood that injection fluids would travel far enough from the well to encounter a fault and cause earthquakes."

5) There may have been an example of induced seismicity, related to a Class II well, in Kansas in 1989. A series of small earthquakes, strong enough to feel, occurred in Rooks County. A paper by Aarmbruster and Steeples noted that the activity occurred in the Marcotte Oil field, and that "one disposal well lies directly above the western, most active part of the zone of seismicity." That well may also have been in proximity to a deeply buried fault zone. "The coincidence of a disposal well, recent pore pressure history, extended swarmy nature of the seismicity, and low level of prior earthquake occurrence in this area allow for the possibility that this seismicity could have been induced." The authors also concluded that "comparing the size of this zone of seismicity with others in the Eastern U.S. suggests that it would not generate events of magnitude greater than (about) 5."

Bottom line: Induced seismicity is not related to hydraulic fracturing. Increased seismic activity in the midcontinent may be manmade, though the jury is still out on the relationship between that activity and waste fluid disposal. Strong evidence does exist supporting the relationship between high pressure (pressure above that naturally found in an aquifer) injection and some specific cases of induced seismicity. There has been one documented instance of a possible association between disposal wells and low-level seismic activity in Kansas.